Classification of Age Distribution of Population by District, and Proposal of its General Index

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Summary: Population numbers are an important factor to consider in developing and managing the development plan of a district. It is also important to consider the individual characteristics of the population such as gender and age. In particular, demands placed on district development differ across generations, so it is necessary to focus on the age distribution of the population. However, there are various types of age categories with different definitions among types. This is complicated because there is no established way of interpreting data at the municipal district level. Furthermore, as there are no rules about arranging the data, it is difficult to intelligently discuss strategies and management of the district using the data. In this study, (1) Cluster analysis is used to classify the district population age groups in the city of Fukuoka by district. Their characteristics are then discussed. (2) General indices such as the proportion of children or the proportion of families are defined using principal component analysis, and characteristics of long-term residence and short term residence are clarified. (3) Finally, district facility development planning is discussed using these indices.

Keywords: Age distribution of population by district, District facility development plan, Cluster analysis

1. Structure of the changing population distribution by district in Fukuoka City

Population is the fundamental index used to discuss and execute a development plan and management strategy at a district level, and the population of Fukuoka City is increasing. From the viewpoint of urban structure, population distribution by individual attributes is rapidly changing as a result of factors such as technological innovation, aging and a declining birthrate.

For example, Figure 1 shows the relationship in the change of population numbers by year between two divided areas in Fukuoka City. One is consists of Chuo and Hakata wards, which is located in central of city, and is defined as city center. The other is consists of all the other wards and is defined as the suburbs. In 2007, the population of Fukuoka City was 1,380,000 (350,000 in the city center and 1,030,000 in the suburbs).

From 1988 to 1991, the population in the city center decreased and that in the suburbs rapidly increased. The scale of growth in the suburbs was brought about by departures from the city center, described as total decentralization.

In the period 1993 to 1995, the population in the city center was slowly decreasing and that in the suburbs was increasing, but the rate of increase was about half that of the previous period. In the period after 1995, the situation changed greatly. The population in the city center increased rapidly, at the same rate as the suburbs. That is to say, the decrease in population changed to a recovery of population in the city center. The growth in the population of
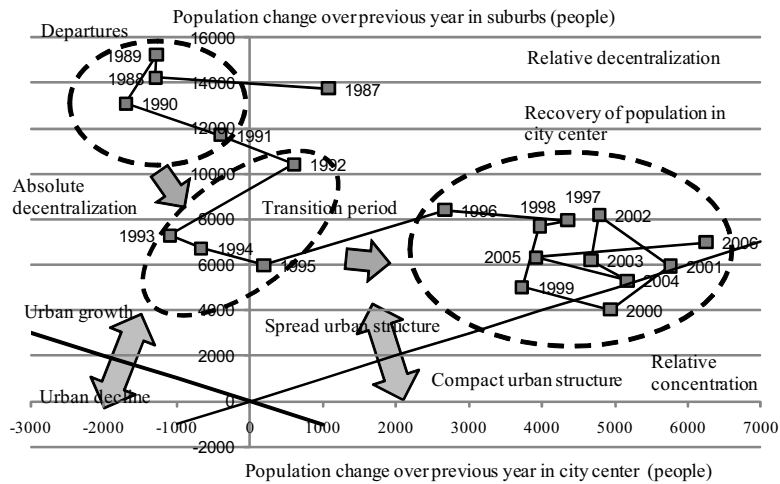
Population change over previous year in suburbs (people)

Departures
16000
1989
Relative decentralization
1988
14000
1987
1990
Recovery of population in city center
13000
1991
Absolute decentralization
10000
1992
Transition period
8000
1996
1998
1997
2002
1993
2005
2003
1994
6000
2000
1999
2004
2001
2006
1995
Urban growth
4000
Spread urban structure
Compact urban structure
Relative concentration
2000
Urban decline
0
-3000 -2000 -1000   0   1000 2000 3000 4000 5000 6000 7000
-2000

Population change over previous year in city center (people)

Figure 1   Urban structure change showing the relationship of annual population changes in the city center and the suburbs

Number of district
Average 538.8 people   Standard deviation 826.8 people
Minimum -1696 people
Maximum 3682 people
District with population increase 30
District with population decrease 81

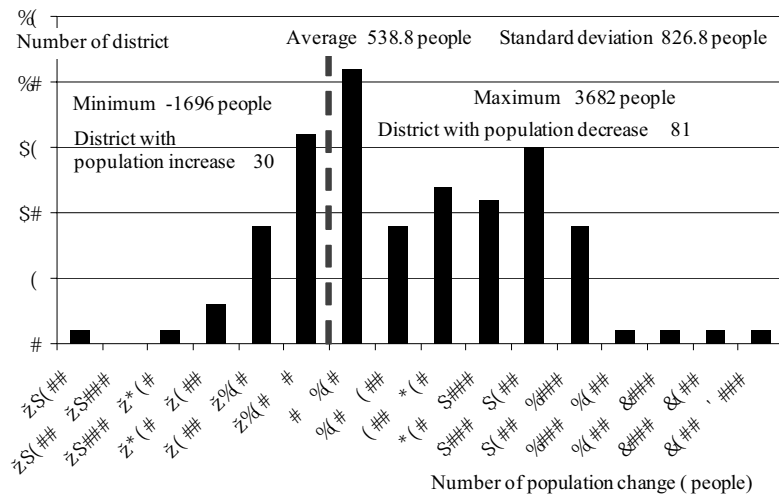Number of population change (people)

Figure 2   Histogram of population change from 2000-2005 by district

the suburbs was still higher than the growth in the city center, resulting in a state of relative decentralization.

In the future, the recovery of the population in the city center will be uncertain. As the population in Kyushu and Japan is decreasing, the recovery of the population in the city center will stop. But the population changes by district are variable, so there are districts with growing populations and districts with declining populations.

Fukuoka city is divided into 111 districts in the national population census (Fukuoka City[1],[2]). Figure 2 shows a histogram of the changing population by district in Fukuoka City from 2000 to 2005. The maximum population by district was 27,261, the minimum 156 and the average 12,624. The average increase of population per district was 538.8 (4.3%).

In 81 districts out of 111 (73%), the population increased. As a result, the population in the whole city increased. But, in 30 districts of Fukuoka City, the population decreased. In five districts, it decreased by more than 500. The maximum decrease in population was 1,696 (9.4%).

These changes of population by district were caused by natural growth, social movement and development of the city center. It is possible to use the national population census and a forecasting technique, which we have developed to analyze in detail the changes in the population, forecast the future population and use these data to discuss the district development strategies (for example, National Institute of Population and Social Security Research[3]).

But, the changes differ among generations and with individual characteristics. For instance, the changes in population of young people, students, workers and families are different across the districts. Therefore, it is

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necessary to understand correctly the quality change of these variables. As gender has only two categories, the quality change of gender is understood by using the population by gender or the population and the rate of gender change. On the other hand, as age categories have various patterns and there are no rules to sort the data by district it is difficult to use it correctly in the discussion of the strategies and management of districts.

For example, in the development of parks, community centers and schools, management of the community and setting up the care system of the elderly, it is necessary to understand the population and its age distribution. Once the differences and characteristics of districts by age distribution are understood, then it is necessary to clarify the importance and the priority of developing competing district facilities based on the allocated budget. But, there is no fixed index and no method to evaluate these factors effectively.

To resolve the issues mentioned above, the strategies were individually evaluated using three classifications of population by age: children (0-14), working-age adults (15-64) and the elderly (65-) in a lot of study. But, these classifications do not adequately enable discussion of the characteristics of age distribution by district or how to describe the difference of age distribution among districts.

In this study, we sought to understand and evaluate, in particular, the population distribution by age in the districts to facilitate discussion of the management and development of the district. First, we analyzed the actual conditions of population by age. That is, the age distribution of the population is classified by using cluster analysis and its characteristics are studied. Based on these results, two indices are proposed and discussed. Using these indices, it is possible to compare generation and age distribution among districts in the evaluation of district development and management strategies. It is of practical use.

2. Classification by age group and district

2. 1 Classification of age group and district

To discuss age distribution of population it is necessary to classify the district and age group. Age group categorized in 5-year bands is usual. Also, population survey data such as natural increase and social increase are divided into 5-year bands. Therefore, this study is analyzed by 5-year age bands, giving 18 categories, The 18 bands are further merged into seven groups by similarity of meaning and spatial distribution (Chishaki and Kajita[4]). Figure 3 shows the seven groups: children (ages 0-14), youths (ages 15-24), young adults (ages 25-34), parenting-aged adults (ages 35-44), middle-aged adults (ages 45-54), the early elderly (ages 55-69) and the elderly (age 70+). Old age, which we define as 60 years old and over, is sub-divided into four stages: pre-stage, early stage, middle stage and late stage. As for the districts, there are many characteristics of districts such as mesh, chou-moku, community association and district. Of course, if the district unit is smaller, it can be analyzed in more detail. But,
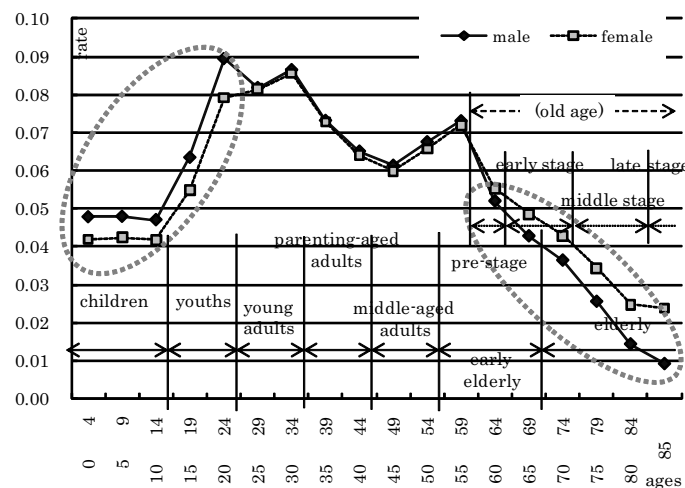

Figure 3 Composition of population by 5-year age bands (Fukuoka City[2])

analysis is difficult because of the need for large data sets and because of missing and abnormal data. Moreover, as district broken down by elementary school catchment area may change as a result of increasing and decreasing numbers of students, it is a problem to get time-series data by district.

As mesh data are generated automatically by latitude and altitude, they cannot be used in district planning. It is usual to discuss the issues of districts by the area of an elementary school, junior high school or neighborhood unit. For these situations, the appropriate method is to adopt the district, which is based on the national population census, for analysis. Therefore, this study analyzed the population distribution by gender and 5-year age bands in districts.

2. 2 Classification of districts

Population distributions by age differ among districts. Cluster analysis (Euclidean distance and Ward's method) is used to clarify the types of distribution. The results are shown in Table 1 and Figure 4.

2. 2. 1 Analysis by gender: male

The results for males are shown in the top section of Table 1. In cluster analysis, the classified group is defined by both the post-merger distance of two districts and similarity of age distribution by trial and error. The result is border post-merger distance of 0.06.111 districts are classified into 20 groups which are merged into eight groups (0.12 and under of post-merger distance). This is shown on the left side of Table 1.

From the Table, on the basis of 20 groups, the number of districts is large in clusters 4, 14, 5 and 6. The sum of these clusters is 75 districts, which covers over two thirds of the total and most of the city area.

Cluster 5 has the largest number of districts at 31, two thirds of which are located in the residential areas of Higashi, Sawara and Nishi wards. Next in order is cluster 14 with 18 districts, which are mostly located in or near the central urban area. Cluster 6 has the third largest number of districts and these are located in a green suburban area.
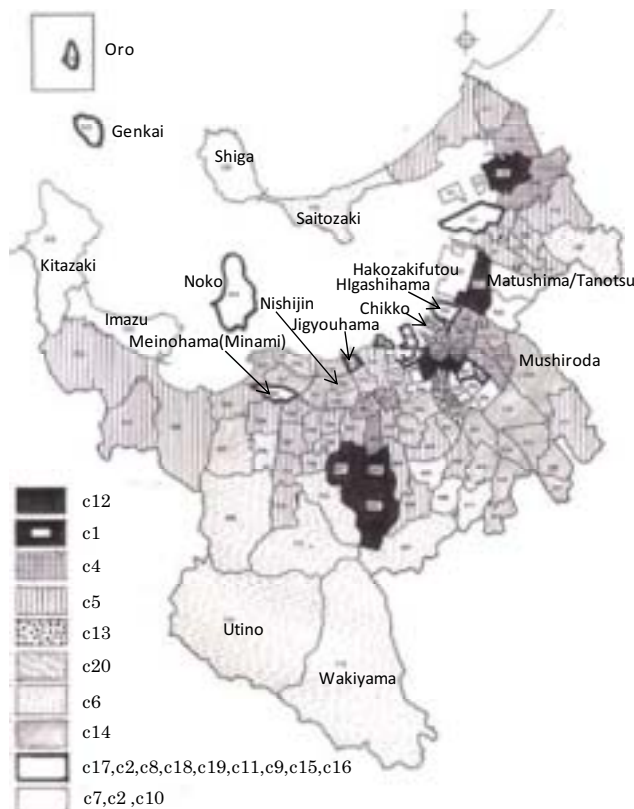

Figure 4 Cluster groups of males by similarity of age distribution

Clusters 1, 2, 7, 10 and 13 are composed of three to seven districts; the sum of districts in these clusters is 23. Districts of cluster 7 are Shika, Kitazaki and Imazu, which are located on the edge of Fukuoka City. Districts of cluster 13 are located next to the central urban area. Those of cluster 2 are mainly located in industrial and distribution center areas.

The rest of the clusters are composed of one or two districts. The age distribution in these clusters is different from the other clusters. The specific districts No.103 (Higashihama) and No.316 (Jigyohama) constitute individual clusters themselves even in the merged classification. Both the districts are reclamation sites. Higashihama is an industrial area and Jigyohama is a new urban development area.

2. 2. 2 Analysis by gender: female

The results for females are shown in lower part of Table 1. By using the method of analysis as applied to males, the data are classified into 19 groups which are further merged into eight groups (0.12 and under of post-merger distance). Cluster 5 has the largest number of districts at 42. Twenty eight of them are the same as those for the male

Table 1 Classification of districts by gender and age group

cluster(male)			District
8 groups	20 groups	number	No. of districts
1	1	5	101,115,605,606,607
	4	12	104,114,116,208,209,210,212,214,215,313,601,603
2	2	3	102,105,106
	17	1	503
	14	18	213,216,218,219,220,221,305,312,401,403,410,413,414,501,502,701,702,7
	10	7	202,204,205,206,306,308,310
3	3	1	103
4	5	31	107,109,110,111,112,113,117,118,217,307,311,314,315,404,406,409,412,504,509,510,511,602,604,704,705,706,707,709,711,712
	6	14	108,119,405,407,408,411,506,507,508,708,710,713,714,715
	8	1	121
	20	2	516,716
5	7	3	120,512,513
	18	1	514
	19	1	515
6	11	1	203
	9	1	201
	15	1	309
	12	2	207,301
7	13	5	211,302,303,304,402
8	16	1	316

cluster(female)			District
8 groups	19 groups	number	No. of districts
1	1	8	101,114,115,210,215,605,606,607
	4	7	104,207,208,214,307,308,311
	9	6	202,204,205,306,310,401
	13	4	302,303,304,402
	14	1	309
2	2	16	102,105,106,216,305,312,313,403,410,413,414,501,601,701,702,703
	16	1	503
3	3	1	103
4	5	42	107,108,109,110,111,112,113,116,117,118,121,213,218,219,220,221,314,315,404,406,407,409,411,412,502,504,505,507,509,510,511,602,603,604,704,705,706,707,708,709,711,712
	19	2	516,716
5	6	8	119,405,408,506,710,713,715
	7	3	120,513,514
	12	2	217,508
6	8	4	201,206,212,301
	10	1	203
	11	2	209,211
7	15	1	316
	18	1	515
8	17	1	512

cluster 5. The next largest number is 16 in cluster 2: Eleven of them belong to the male cluster 14; three districts of cluster 2 male are included. Moreover, the number of districts in clusters 1, 4, 6 and 9 is six to nine districts, the sum is 87 and they occupy 80% of 111 districts.

Thirteen clusters are composed of only one or two districts. The specific districts No.103 (Higashihama) and No.512 (Imazu) constitute individual clusters even in the merged classification.

3. Characteristics of the population classified by age group

There are 20 clusters for males and 19 clusters for females, as shown in Figures 5 and 6 and Table 2. Table 3 shows the characteristics of the populations.

Comparing Figures 5 and 6, even cluster 5, which has the largest number of districts for both male and female, has different proportions of population by age group. An analysis by district is therefore necessary to get a clear understanding of the distribution.
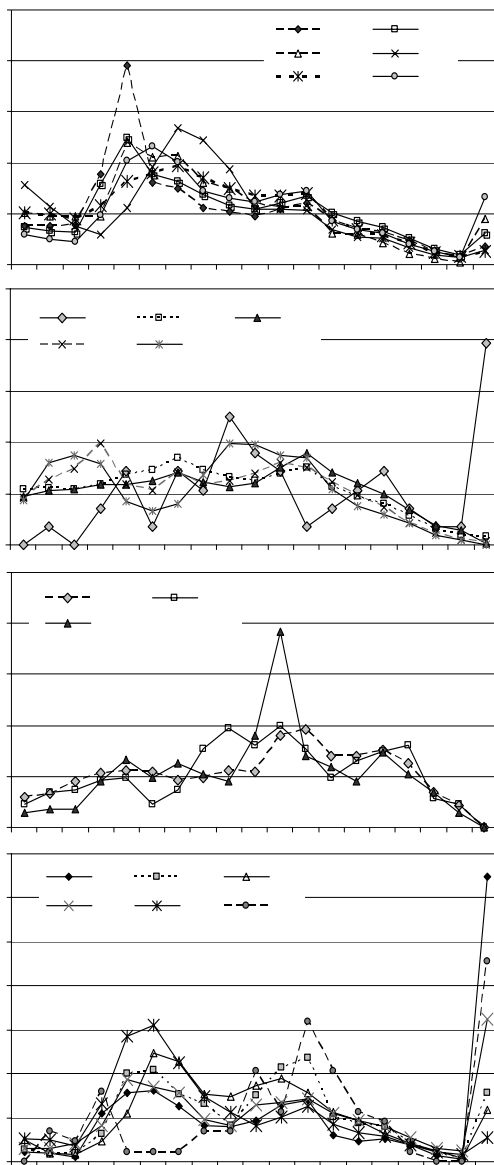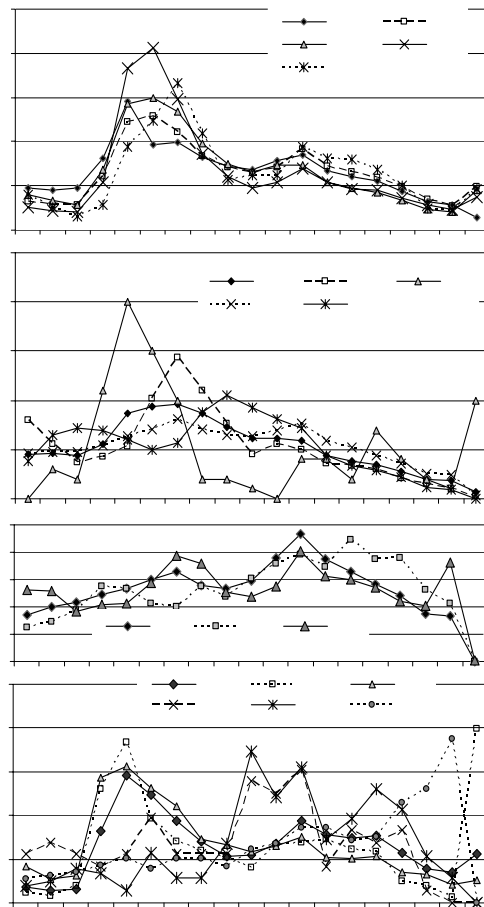
Figure 5 Age distribution by clusters: male

Figure 6 Age distribution by clusters: female

3. 1 Analysis by gender: male

a. High proportion of children.

In clusters 5, 17, 8 and, 20, the proportion of children ranges from 17-21%; this proportion is higher than that of the city as a whole. These clusters, except cluster 17, belong to group 4 in the merged classification. There is also a high rate in the remaining cluster (6) in this group. This means that group 4 in the merged classification overall has a high proportion of children.

b. High proportion of families (child (ren) and parent) stage.

In clusters 17 and 20, the sum of children and parenting-aged adults is 38-39%. The ratio of parenting-aged adults stage in cluster 17 and that of children in cluster 20 are high, both proportions are 21%.

c. High proportion of elderly.

The total proportions of early, middle and late old stage range from 22-27 % in clusters 7, 18 and 19. These districts belong to group 5 in the merged classification. This group has the highest proportion of elderly in Fukuoka City. These districts are mainly located on islands or on the peninsula.

Table 2 Proportions of age group in each cluster

Cluster (Male)		children	youths	young adults	parenting-aged adults	middle-aged adults	early elderly (55-64)	early old (65-74)	middle and late old (75-)
8 Groups	20 Groups								
1	1	0.114	0.279	0.158	0.109	0.102	0.104	0.068	0.045
	4	0.108	0.211	0.167	0.126	0.115	0.118	0.079	0.051
2	2	0.146	0.167	0.212	0.156	0.116	0.088	0.051	0.020
	17	0.173	0.085	0.231	0.216	0.108	0.088	0.052	0.033
	14	0.145	0.140	0.189	0.159	0.136	0.114	0.064	0.041
	10	0.078	0.149	0.216	0.139	0.131	0.116	0.066	0.041
3	3	0.018	0.107	0.089	0.179	0.161	0.054	0.125	0.071
4	5	0.168	0.126	0.156	0.142	0.132	0.128	0.086	0.053
	6	0.155	0.118	0.133	0.117	0.137	0.159	0.111	0.069
	8	0.183	0.159	0.124	0.122	0.150	0.137	0.085	0.037
	20	0.210	0.121	0.074	0.167	0.185	0.139	0.067	0.036
5	7	0.105	0.111	0.104	0.105	0.146	0.170	0.144	0.115
	18	0.094	0.094	0.060	0.174	0.180	0.126	0.140	0.131
	19	0.049	0.111	0.111	0.098	0.282	0.129	0.118	0.101
6	11	0.027	0.133	0.144	0.081	0.112	0.101	0.050	0.027
	9	0.033	0.131	0.181	0.107	0.181	0.168	0.083	0.036
	15	0.043	0.078	0.238	0.151	0.181	0.134	0.078	0.037
	12	0.051	0.134	0.164	0.090	0.131	0.126	0.086	0.056
7	13	0.070	0.217	0.270	0.124	0.091	0.108	0.063	0.031
8	16	0.057	0.091	0.023	0.068	0.159	0.261	0.102	0.011
whole area		0.146	0.155	0.169	0.140	0.131	0.128	0.081	0.050

Cluster (Female)		children	youths	young adults	parenting-aged adults	middle-aged adults	early elderly 55~64	early old 65~74	middle and late old (75-)
8 Groups	19 Groups								
1	1	0.112	0.185	0.154	0.122	0.118	0.122	0.093	0.084
	4	0.072	0.145	0.193	0.126	0.109	0.132	0.100	0.086
	9	0.081	0.170	0.227	0.138	0.112	0.102	0.073	0.062
	13	0.054	0.190	0.284	0.118	0.081	0.098	0.074	0.071
	14	0.066	0.098	0.232	0.133	0.099	0.140	0.118	0.077
2	2	0.147	0.142	0.185	0.168	0.124	0.092	0.071	0.061
	16	0.172	0.097	0.246	0.187	0.101	0.085	0.064	0.046
3	3	0.050	0.310	0.250	0.040	0.010	0.080	0.090	0.070
4	5	0.142	0.118	0.150	0.135	0.133	0.134	0.095	0.090
	19	0.175	0.129	0.107	0.193	0.173	0.116	0.063	0.043
5	6	0.123	0.096	0.122	0.112	0.133	0.159	0.128	0.126
	7	0.088	0.108	0.084	0.103	0.132	0.151	0.164	0.170
	12	0.140	0.084	0.135	0.123	0.102	0.144	0.114	0.157
6	8	0.035	0.178	0.174	0.096	0.102	0.144	0.122	0.104
	10	0.031	0.251	0.134	0.090	0.086	0.114	0.096	0.040
	11	0.080	0.240	0.194	0.112	0.099	0.102	0.083	0.071
7	15	0.144	0.078	0.122	0.089	0.211	0.156	0.122	0.078
	18	0.075	0.075	0.072	0.074	0.103	0.137	0.118	0.346
8	17	0.066	0.039	0.069	0.077	0.236	0.181	0.181	0.151
whole area		0.128	0.134	0.167	0.138	0.127	0.129	0.093	0.084

d. High proportion of people in their 20s.

The proportion of those in their 20s comprises about one third of cluster 13 while the total proportion of youths and young adults comprises 50%.

e. Peak of specific stages.

Cluster 1 has the peak of 20s, cluster 3 has the peak of 40s, cluster 19 has the peak of 50s and cluster 16 has the peak of 55s.

3. 2 Analysis by gender: female

a. High proportion of children.

The proportion in clusters 19 and 16 is higher than the whole city for children. Districts such as Atagohama, Momochihama and Meinohama-minami, which are included in these clusters, have recent housing developments.

b. High proportion of family stage.

Clusters 19, 16 and 2 have high total proportions (32-37%) of children and parenting-aged adults.

c. High proportion of elderly.

The districts belonging to clusters 6, 7, 12, 17 and 18, have an over 25% proportion of elderly. The highest proportion is 46% in cluster 18. There is a hospital, a day-care center and a welfare facility located in clusters 17, which has only one district, No.512. Those in cluster 12 are mainly located in suburbs of the city. The others are located on islands, the peninsula and in the mountains.

Table 3 Characteristics of clusters by age distribution

a) Male

Cluster		Characteristics
1	c1	Districts with a large sized university or near it. They are characterized by the peak of 20s years and 25% of youths.
	c4	Districts with colleges in the central area of the city, and they are characterized by the comparative large rate of youths.
2	c2	Rate of young adults are comparatively high under the similar type of age distribution as in the city.
	c17	Only a district with residential houses, Meinohama(minami). Rates of young adults and parenting-aged adults are large.
	c14	Although the shape of age distribution is as similar as in the city, rates of young adults and parenting-aged adults are a little large, while rates of middle-aged adults and old age are somewhat small.
	c10	Rate of young adults is high, while the rate of children is low.
3	c3	Higashihama district in which population is only 56. Most of population are workers related to port and their families. Rates of the early elderly and of parenting-aged adults are large, though the rate of children is small.
4	c5	Although the shape of age distribution is similar as in the city, rate of children is comparatively large and the one in young adults is a little small.
	c6	Peak at the unit of 55 years old. Rates of middle-aged adults and the early elderly are large, while rates of young adults and parentig-aged adults are small.
	c8	Although districts belong to c5, rate of children is comparatively large under the similar age distribution of the city.
	c20	Rate of children is large. Although rates of middle-aged adults and parenting-aged adults are large, rates of youths and young adults are small.
5	c7	Rates of the early old age and middle-aged adults are large in comparison with others. The first step of aged society is advancing.
	c18	There are two peaks of the 35 to 59 and the 65 to 79 years old. Super-aged society with 25% of the rate of over 65 years old.
	c19	Peak of the 50s ages is high, while rates of children, youths and young adults are small.
6	c11	District in this cluster is Hakatahigashi, in which the group of unknown ages is 32%. The 55 to 65 years old is half of population.
	c9	There are two peaks of the 50s ages and 20s ages. In them, the peak of the 50s ages is higher than other.
	c15	The distributions of districts are almost same as the city, though rates of children and youths are lowered and rates of young adults and middle-aged adults are higher.
	c12	Districts near the central area. Rate of unknown ages is 16% and rate of young adults is rather high.
7	c13	Rate of the 20s ages is 30%, and the 15 to 34 years old is half. Districts of this cluster is the town of youths and young adults.
8	c16	Matured society. Rates of middle-aged adults and the early elderly are large. The sum of their rates is 44%.

(b) Female

Cluster		Characteristics
1	c19	Almost same as the c1 of male. Although there are a peak at the 20s ages, the shape of age distribution is similar to the city.
	c4	Although the rate of children is a little small, the shape of age distribution is similar to the city.
	c9	The rate of the late 20s to early 30s ages is large comparatively . The total of their rates is about 1/3.
	c13	Rate of 20s ages is 30%. Rate of the 15 to 34 years old attains to half.
	c14	Peak is presented at the 30s ages, and rate of the 20s to 30s ages is about 40%.
2	c2	Although there is no peak, rate of the 20s to 30s ages is 36%.
	c16	Age distribution is similar to c14 and rate of the 25 to 34 years old is 36%.
3	c3	Districts in this cluster are same to c3 of male. Although the population in these districts is slightly 1000, the rate of the 20s ages is a peak, and the rate of the 15 to 30 years old is 56%.
4	c5	Rates of youths and young adults are comparatively small, while ones of middle-aged adults and the early elderly are large.
	c19	Rate of parentig-aged adults is 37% and rate of over 60 years old is small.
5	c6	This cluster is same to c6 in male. There is the peak at the unit of 55 years old, and rate of middle-aged adults and the early elderly is comparatively high.
	c7	Rate of the aged is large and districts in this cluster are the super-aged society in which rate of over 65 years old is about 1/3.
	c12	There is the peak at the unit of 55 years old, and rate of over 65 years old reaches 27%.
6	c8	Districts have big rate of young adults and the peak of the 20s ages. Rate in youths and young adults is 39%.
	c10	This cluster is same to c11 in male. Rate of unknown ages is 16%.
	c11	The cluster is similar to c10. Rate of young adults is large and total of youths and young adults reaches to 43%.
7	c15	The rate of middle-aged adults and the early elderly is large
	c18	Island. Rate of the middle and late old age is 35%. Super-aged society of 46% of over 65years old.
8	c17	Districts have many hospitals and welfare facilities. The rate of over 45 years old occupy 3/4.

d. High proportion of those in their 20s.

Cluster 3 has 35%, cluster 13 has 31% and cluster 9 has 23%. The proportion of those in their 30s in these clusters is about 10%. There are many young people in these districts, which are located near the central urban area.

e. High proportion of young adults.

Clusters 3, 10 and 11 have higher proportions of children than the other clusters. Also, considering the relatively high proportion in cluster 8, districts in groups 3 and 6 in the merged classification have high proportions of young adults.

f. Peaks at specific stages.

Cluster 3 (Higashihama) and cluster 10 (Hakataeki-higashi) have peaks for those in their 20s, and cluster 14 (Nagahama, Nanotsu) and cluster 16 (Meinohama-minami) have peaks for thiose in their 30s. Each cluster comprises only one district.

4．General index of age distribution

To discuss the development of the district in detail spatial distribution of population by age group is necessary. Although it is easier to understand this by an evaluation of general numerical data on a case by case basis, it is good to use the both approaches.

Some representative indices of population distribution by age group are:

1. Average age
2. Four age groups, which are young, working, old and late old, with their numerical bands.

However, to understand the detail, it is proposed to use the following indices in this study.

3. Seven age groups, which are children, youths, young adults, parenting-aged adults, middle-aged adults, the early elderly and the elderly with their numerical bands.
4. Cluster groups by age distribution, which have already been analyzed in this study.

It is appropriate to discuss the development plan of the district using population, population density and the indices as mentioned above. Also, it is necessary to discuss importance and priority for the development plan by comparison with districts based on age distribution. In that case, the general index based on age distribution is better than the individual indices like 2 to 4. This point is discussed below.

Table 4　Results of principal component analysis by age distribution using 2005 national population census data.

Age \ P.c.	Male				Female			
	Z1	Z2	Z1	Z2	Z1	Z2	Z1	Z2
Eigenvalue	0.0023	0.0010	Degree of youth	Degree of family	0.0023	0.0011	Degree of youth	Degree of family
Contributing rate	0.4517	0.1960			0.4776	0.2311		
Cum. cont. rate	0.4517	0.6477			0.4476	0.7087		
Ages unit	Eigenvector		Loading facor		Eigenvector		Loading facor	
0-4	-0.0798	0.3134	-0.2554	**0.6606**	-0.0922	0.2969	-0.3359	**0.7522**
5-9	-0.1727	0.2192	-0.5287	0.4419	-0.1433	0.3007	-0.5001	**0.7301**
10-14	-0.1994	0.1348	-0.5773	0.2572	-0.1749	0.2497	**-0.6267**	**0.6225**
15-19	0.0701	-0.2031	0.2114	-0.4038	0.0958	-0.0300	0.2951	-0.0642
20-24	0.7063	-0.3660	**0.9083**	-0.3101	0.6025	-0.2300	**0.9189**	-0.2440
25-29	0.4476	0.2675	**0.8133**	0.3202	0.5024	0.0013	**0.9226**	0.0017
30-34	0.2219	0.4286	0.5658	**0.7199**	0.2869	0.2918	**0.7005**	0.4956
35-39	0.0373	0.3857	0.1292	**0.8796**	0.0508	0.3868	0.1649	**0.8738**
40-44	-0.0514	0.2773	-0.1735	**0.6169**	-0.0494	0.3256	-0.1817	**0.8321**
45-49	-0.1407	0.0531	-0.5596	0.1392	-0.1925	0.1408	-0.6473	0.3295
50-54	-0.1757	-0.1021	-0.5235	-0.2005	-0.1987	0.0607	**-0.7720**	0.1640
55-59	-0.1750	-0.1629	-0.5530	-0.3391	-0.2106	-0.1285	**-0.7108**	-0.3017
60-64	-0.1637	-0.1858	**-0.6110**	-0.4570	-0.1382	-0.1586	-0.5741	-0.4583
65-69	-0.1508	-0.1776	**-0.6095**	-0.4730	-0.1655	-0.2037	**-0.6343**	-0.5434
70-74	-0.1411	-0.2057	-0.5566	-0.5344	-0.1049	-0.2644	-0.4193	**-0.7353**
75-79	-0.1114	-0.1519	-0.5031	-0.4518	-0.1422	-0.2805	-0.5225	**-0.7170**
80-84	-0.0486	-0.0757	-0.3947	-0.4051	-0.0993	-0.2272	-0.4186	**-0.6664**
85-	-0.0339	-0.0493	-0.3322	-0.3180	-0.1415	-0.2400	-0.3946	-0.4655

4. 1 The proposal of principal component scores index

We can use the principal component scores themselves for general understanding of age distribution by district because these scores are composed of variables based on data by district.
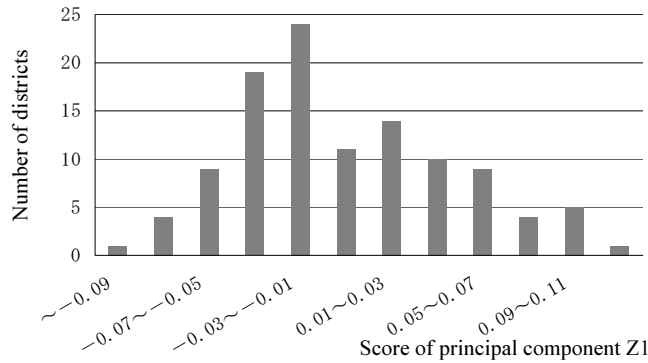

Figure 7　Distribution of first principal component scores: male

Table 5　Classification of districts by principal component scores

District		Principal component Z2		
		large	middle	small
Principal component Z1	large	402,102,106	211,303,302 304,202,205	607,115,605,606 114,212,104
	middle	701,216,501 218,503,309	311,602	
	small		516,507,108 405,121	316,514,512,513 515,120,715,714

Note:　　large：top 20　（Z1≧0.0491,Z2≧0.0207）
　　　　　　middle：from −0.01 to +0.01　（Score is almost zero）
　　　　　　small：low-ranking 20　（Z1≦−0.0435, Z2≦−0.0297）

Table 4 shows the eigenvector and loading factor of the first component (Z1) and the second component (Z2) by age distribution of gender in districts using the 2005 national population census. About two thirds of all characteristics in both of male and female are included in two factors.

In both genders, Z1 is high if the proportion of those in their 20s and 30s is high. On the other hand, Z1 is low if the proportion of those 5-14 years and 45-80 years is high. From this result, this is called the proportion of youth.

Z2 is high if the proportion of children or those in their 30s-40s is high. It is low if the proportion of the elderly is high. That is to say, it indicates the rate at which family households trend toward the nuclear family. This is called the proportion of families.

In districts that have high Z1 and Z2 scores, the proportion of middle aged is low and that of children and families is high. On the other hand, in districts with low Z1 and Z2, the proportions of children and family are low and the number of the aged is growing.

For the 111 districts in Fukuoka City, for males, the principal component score of Z1 range from -0.1164 to 0.1211 and for Z2 range from -0.0865 to 0.1. Figure 7 shows a histogram of Z1 scores. It has a mountain type distribution. The case for the females is the same.

For males, districts having low Z1 scores belong to clusters 16, 20, 18, 7, 8, 19 and 6. These districts have high proportions of adults and the early elderly, or the elderly. Those having high Z1 scores belong to clusters 13, 1 and 2 which have a high proportion of youth.

Z2 is high in all districts of clusters 16, 19 and 7, and in some districts in clusters 1, 4 and 12. On the other hand, it is low in all districts of cluster 17 and some districts of clusters 2, 14 and 13. The proportion of those in

their 20s is high and its distribution is similar to the whole city's distribution.

Table 5 shows the classification of districts cross tabulated between Z1 and Z2. There are three districts having high Z1 and Z2 scores. No.402 (Okusu) is near the central city and residential area. No.102 (Hakozakifuto) and No.106 (Matsushima and Tanotsu) are in industrial areas or semi-industrial areas and there are many apartments and houses where many children and family live.

There are eight districts having low Z1 and Z2 scores. These are mostly located on islands (No.514 and 515), on mountains (No.714 and 715) and on the peninsula (No.120, 512 and 513) and have decreasing and aging populations. No.316 (Jigyohama) has a hospital, a baseball stadium, a large shopping mall and consulates. It is a new urban area with low population density.

As mentioned above, it is useful to use principal component scores themselves for understanding districts by age distribution. But, these scores vary with social and economic situations, therefore, we have to set the standard year by principal component analysis and recalculate if the situation changes.

4. 2 The usage of residence index by long or short term

Length of residence influences the age distribution in the district. It also influences the development strategy in the district. Table 6 shows the ratios of long or short-term residence by gender based on residence period by age distribution in Fukuoka City (Fukuoka City[5]). Here, long-term residence means a person has lived at a particular place for over 10 years, including a 10-year old child who has lived in the same place since birth. Similarly, short-

Table 6 The ratios of short and long-term residence in Fukuoka City

Unite of ages	Resident ratio			
	Male		Female	
	less than 5 years	over 10years	less than 5 years	over 10years
0 4	0.9951	0	0.9942	0
5 9	0.5015	0	0.5015	0
10 14	0.3701	0.3451	0.3715	0.3498
15 19	0.4694	0.3524	0.4433	0.3735
20 24	0.6156	0.2266	0.5962	0.2636
25 29	0.6049	0.2021	0.6246	0.2088
30 34	0.6156	0.1601	0.6069	0.1563
35 39	0.5276	0.1894	0.4919	0.2176
40 44	0.4337	0.2905	0.3673	0.3613
45 49	0.3454	0.4179	0.2828	0.4951
50 54	0.2958	0.5082	0.2414	0.5876
55 59	0.2453	0.5955	0.1949	0.6674
60 64	0.1964	0.6626	0.1685	0.7075
65 69	0.1467	0.7150	0.1587	0.7220
70 74	0.1383	0.7409	0.1551	0.7346
75 79	0.1351	0.7356	0.1837	0.7037
80 84	0.1625	0.7152	0.2457	0.6421
85	0.2331	0.6500	0.3438	0.5314

Note:Population in total includes the unknown period of residence.

Table 7 Districts with higher and lower rank of residence index for long or short terms by gender: female

Long-term residence					Short-term residence				
District	small	District	large		District	small	District	large	
503 Meinohama(Minami)	0.328	515 Genkai Oro	0.543		515 Genkai Oro	0.289	503 Meinohama(Minami)	0.469	
103 Higashihama	0.331	512 Imazu	0.515		512 Imazu	0.325	106 Matushima Tanotu	0.453	
106 Matushima Tanotu	0.342	120 Shiga	0.500		120 Shiga	0.328	402 Ookusu	0.448	
202 Hakataekiminami	0.344	514 Noko	0.496		514 Noko	0.332	304 Shiragane Takasago	0.448	
702 Nishijin	0.346	513 Kitazaki	0.486		715 Wakiyama	0.338	401 Tamagawa	0.444	
304 Shiragande Takasago	0.354	715 Wakiyama	0.485		301 Tenjin	0.340	702 Nishijin	0.443	
203 Hakataekihigashi	0.356	714 Utino	0.460		203 Hakataekihigashi	0.341	303 Kiyokawa	0.441	
216 Mushiroda	0.356	119 Saitozaki	0.456		513 Kitazaki	0.342	105 Hakozaki(Higashi)	0.435	
302 Haruyoshi	0.357	408 Hanabatake(higashi)	0.454		207 Reizen	0.346	216 Mushiroda	0.433	
102 Hakozakifutou	0.357	506 Iki(Higashi)	0.451		714 Utino	0.358	211 Chikko	0.399	

Table 8 Relationship between general indices for females

General Index	Long-term residence index	Short-term residence index	Z1(youth degree)	Z2(family degree)
Long-term residence index	1			
Short-term residence index	-0.861	1		
Z1(youth degree)	-0.777	0.606	1	
Z2(family degree)	-0.581	0.712	0	1
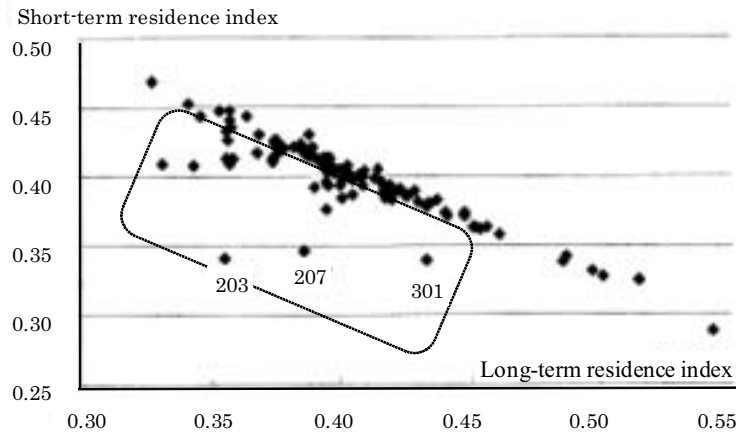
Figure 8 Relationship of residence index of long and short terms by gender: female.

term residence means a person lives at a particular place for less than 5 years. There are differences between the genders.

In each district, the evaluation value is calculated using long or short-term residence ratio and number of population by age distribution. This expresses the potential of long or short-term residence. In this paper, it is called this the long or short-term residence index.

Table 7 shows the higher and lower ranks of the residence index for long or short periods for females by district. The long-term residence index ranges from 0.328-0.543; districts with high index rating are mostly located on islands, the peninsula and in mountain areas, where the proportion of aging population is high. On the other hand, short-term residence index is between 0.289-0.469. Districts with high ranking index numbers are near the university and surrounding the city center.

Figure 8 shows the relationship between the short-term residence index and the long-term one. Naturally enough, they have considerable relationship. But there are some differences in No.203 (Hakataekihigashi), 207 (Reizen) and 301 (Tenjin). These districts are located in the central city area and have low proportions of families. These districts have a lower short-term residence index.

4. 3 The relationship between the general indices

Four general indices are proposed in this study. Table 8 shows the relationships between indices for females. The correlation ratio between principal component score Z1 and Z2 is zero. Also, we can see the considerable relationship between long term and short term in Figure 8. This correlation ratio is -0.861. In addition, there is a small negative correlation between the long-term residence index and the principal component index and there is a small positive relationship between short-term residence index and principal component index.

On the basis of these results, the four proposed indices each express a characteristic of age distribution. It is desirable to use some of the four indices on a case by case basis.

5. Scheme for district facilities development planning

The characteristics of age distribution by type of cluster are required for district facility development planning and management. These are important to know how to proceed with the planning.

Requirements for district facilities and management are different for different generations. For example, Table 9 shows the list of required district facilities by age distribution.

Table 9 shows the list of required district facilities by age distribution.

| Facilities	children	youths	children	parenting-aged adults	middle-aged adults	early elderly	early and middle old age	late old age
open spaces & parks	open space equipped with play facilities	multi-purpose park and playing fields, etc.		child care park	open space for individual exercise		walking paths, park with amenities	
district road	safe and reliable roads for school by universal design	rapport road		roads for living, shopping road, community road, etc.		walking paths, with resting facilities		
						roads by universal design		barrier-free roads
	paths designed for bicycles, wheelchairs and pedestrians to reduce accidents between users; to provide ample parking for bicycles, to ensure ground level access without stairs							
public hall meeting place or hall	study room and library, opening of school facilities	meeting hall for the use of young people including music hall facilities	meeting hall for information exchange	meeting place for hobbies and cultural activities	meeting hall for social contribution, hobbies, cultural activities, etc			meeting hall for social exchange
medical facilities	medical facilities for children	one's doctor			medical facilities for middle ages and the early elderly			care-services
living facilities	child care facilities	residential facilities for the handicapped		useful facilities for living				facilities for living-support
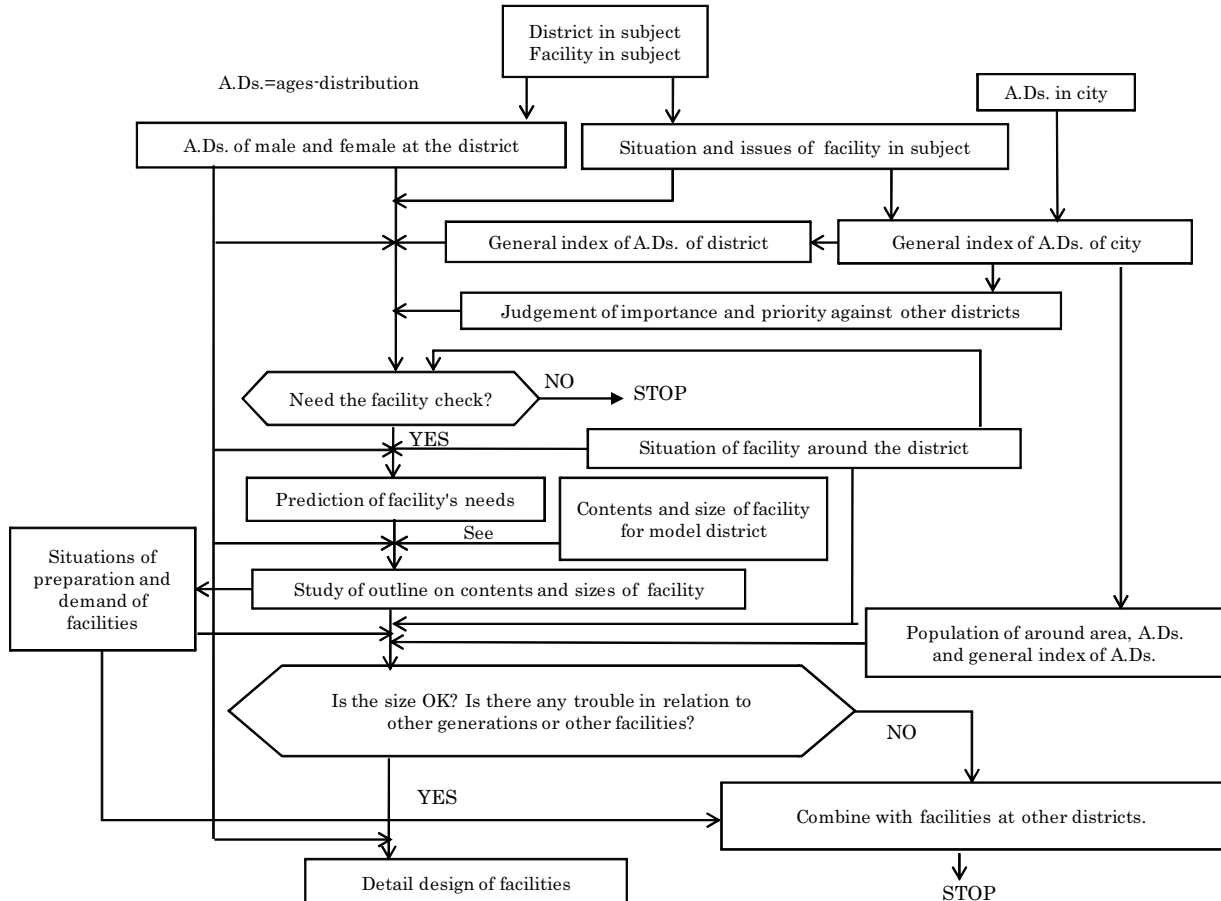
Figure 9 Flow chart for development planning for district facilities

For open space and parks, children want the open space equipped with play facilities, while middle-aged adults and the early elderly want open space for keeping healthy, and aged people want the footpath and park for amenity. For the neighborhood roads, issues to be considered include the use of bicycles and wheelchairs（for example, cyclist and pedestrian paths, developments to prevent traffic accidents, parking lots for bicycles, and smooth ground level entrances without stairs）. Children need safe and reliable roads to get to school, young adults want spaces to gather in, and middle-aged and elderly people want paths for walking, with resting facilities, using universal design for barrier-free roads.

Judgment of the importance, priority, scale and content of district facilities development and management varies with generations and the requirements according to the characteristics of age distribution and different requirements of the generations.

First, a district facility development plan is proposed as a basic model using the age distribution of cluster 5, which has the largest number of districts. The plans for districts, which have similar age distributions to cluster 5, are proposed using the basic model. The plans for districts, which have dissimilar age distributions to cluster 5 are proposed by modifying the basic model. This is the most efficient process.

Figure 9 shows a flow chart of the process of the development of district facilities using general indices and age distribution.

Step ___ : situation and issues of facility in a subject district are surveyed.

Step ___ : the need for a facility development plan and management strategy in a district is checked based on age distribution of males and females in the district, its general indices, comparison of priority and importance to other districts in the city, and the existence of similar facilities in surrounding districts.

Step ___ : if the facility is not needed, the discussion is stopped. On the other hand, if it is needed, the facility user demand is forecast based on age distribution.

Step ___ : requirements for the contents and size of the facility are studied with reference to similar facilities in the subject district and in a model district.

Step ___ : validity of the results of the study is checked based on the situation and existence of facilities in the subject district.

Step ___ : if the results are valid, the detailed design of the facility is considered. If the size of the facility is small, combining with facilities in another district or with other facilities in the same district is studied.

Table 10 shows the summary of the results using the proposed general index efficiently.

Table 10　The meaning of the general index

Type of principal component			
Z2 / Z1	large ⟶		small
large	majority of youth and family	balanced age distributions except for relative large youth	majority of youth
↓	balanced age distributions except for relative large family	no majority of geneartion	balanced age distributions except for relative small family
small	majority of family	balanced age distributions except for youth	majority of old age

Type of occupation			
Short-term residence index / Long-term residence index	large ⟶		small
large		large possibility in long-term residence firstly, and next medium-term residence	large possibility of long-term residence
↓	large possibility in short-term residence firstly, and next medium-term residence	balanced ages with long and short-term residence	balanced ages with long and medium-term residence
small	large possibility of short-term residence	balanced ages with short and medium-term residence	large possibility of medium-term residence

6. Conclusion

Given the declining citywide birthrate and aging society, district facility development and management planning based on age distribution of population are discussed in this study. The summary of results is as follows:

(1) Age distribution in districts by gender is classified using cluster analysis. Males are classified into 20 groups and females into 19. Both are then merged into eight large groups. Cluster 5 has most districts in both male and female analysis and occupies about one third of the total area. These districts are located in the city center or in the area surrounding the city center.

(2) Figures 5 and 6 show distribution of age by cluster. Also these characteristics are shown in Tables 2 and 3. It is clear that children, youths, middle-aged adults and the early elderly each have predominant characteristics.

(3) The use of principal component scores is proposed for general evaluation of age distribution. As a result, the proportions of children and families are proposed based on first and second principal component scores, and this is useful as a general index of age distribution.

(4) Long and short-term residence indices are proposed as one more general index. These indices are mutually related. But, they are not completely the same nor are they related to principal component scores. Four indices are needed to understand the characteristics of age distribution by district.

(5) The process of development planning for a district facility is proposed using the pattern or general indices based on age distribution by district. The result is shown in Figure 9.

Indeed, in step with the decreasing birthrate and aging society, the population growth rate of Fukuoka City will slow in the future. In that situation, the characteristics of age distribution will change over time in each district. Therefore, it is important to draw up and effectively and efficiently manage the district facility development plan, taking into consideration not only quantities such as population scale but also qualities such as age distribution. To achieve this, it is expected that making better use of proposed classification of age distribution and the two types of general index used in this study will be very useful.

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